Advanced multiscale material studies for future fusion power

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Abstract:

Development of advanced structural materials for nuclear power requires overcoming several material design, synthesis and testing challenges. For fusion, tungsten (W) is considered to be the best candidate as a plasma material interface (PMI). However, W, as a PMI, will be exposed to a high energy neutron flux and the intense plasma which can trigger detrimental changes to the microstructure and the mechanical properties. Addressing these issues via designing irradiation resistant materials (e.g. nc materials and alloys) and investigating their performance is crucial. Here, I will present multiscale phenomena in irradiated tungsten materials as a step to generate a “figure of merit” correlating materials morphological and mechanical response with irradiation parameters. For small scale studies, in-situ low energy helium irradiations and high energy heavy ion irradiation on several tungsten grades (nanocrystalline, ultrafine, coarse grained, alloys and refractory high entropy alloys) are performed. Defect densities, sizes and the overall swelling as a function of grain size is presented based on transmission electron microscopy images. The effect of grain boundary density on limiting the irradiation damage is quantified. The grain boundary sink efficiency is discussed based on denuded zone formation. At the large scale, nanoindentation and micropillar compression tests before and after irradiation (e.g. nanocrystalline tungsten samples with helium bubble-loaded grain boundaries) are discussed. Conclusions regarding the advantages and possible disadvantages of using pure nanocrystalline tungsten materials and nanocrystalline high entropy alloys are presented.

Bio:

Dr. El Atwani is an early career scientist at LANL. Prior to joining LANL, El Atwani worked on irradiation damage of ultrafine and nanocrystalline tungsten (for fusion applications) and iron (for fission applications) materials and ion beam interaction/surface modification of semiconductor and metallic surfaces. In 2016, after two postdoctoral positions at Purdue University and Drexel University, El Atwani was accepted as a Director Postdoc Fellow at LANL and in 2017, he also earned a Seaborg fellowship. His work at LANL earned him the FY18 Postdoctoral Distinguished Performance Award. El Atwani is currently working on multiscale fundamental and application studies on nanocrystalline metals, high entropy alloys, and cladding candidate materials including morphology and damage evolution under irradiation, mechanical properties and the role of grain boundaries and interfaces in mitigating irradiation damage. He has a patent and about fifty publications outlining his experience in ion beam interaction, irradiation resistance, grain boundary effects and electron microscopy and surface science studies of materials. He has a Ph.D. degree in Materials Engineering from Purdue University (United States), M.S. degree in Materials Science from Sabanci University (Turkey) and B.S. degrees in Chemistry and Chemical Engineering from Middle East Technical University (Turkey).